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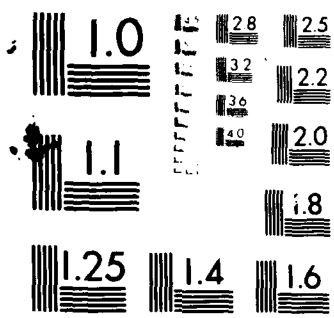

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QUANTIFYING SEAPOWER READINESS

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Naval Studies Group

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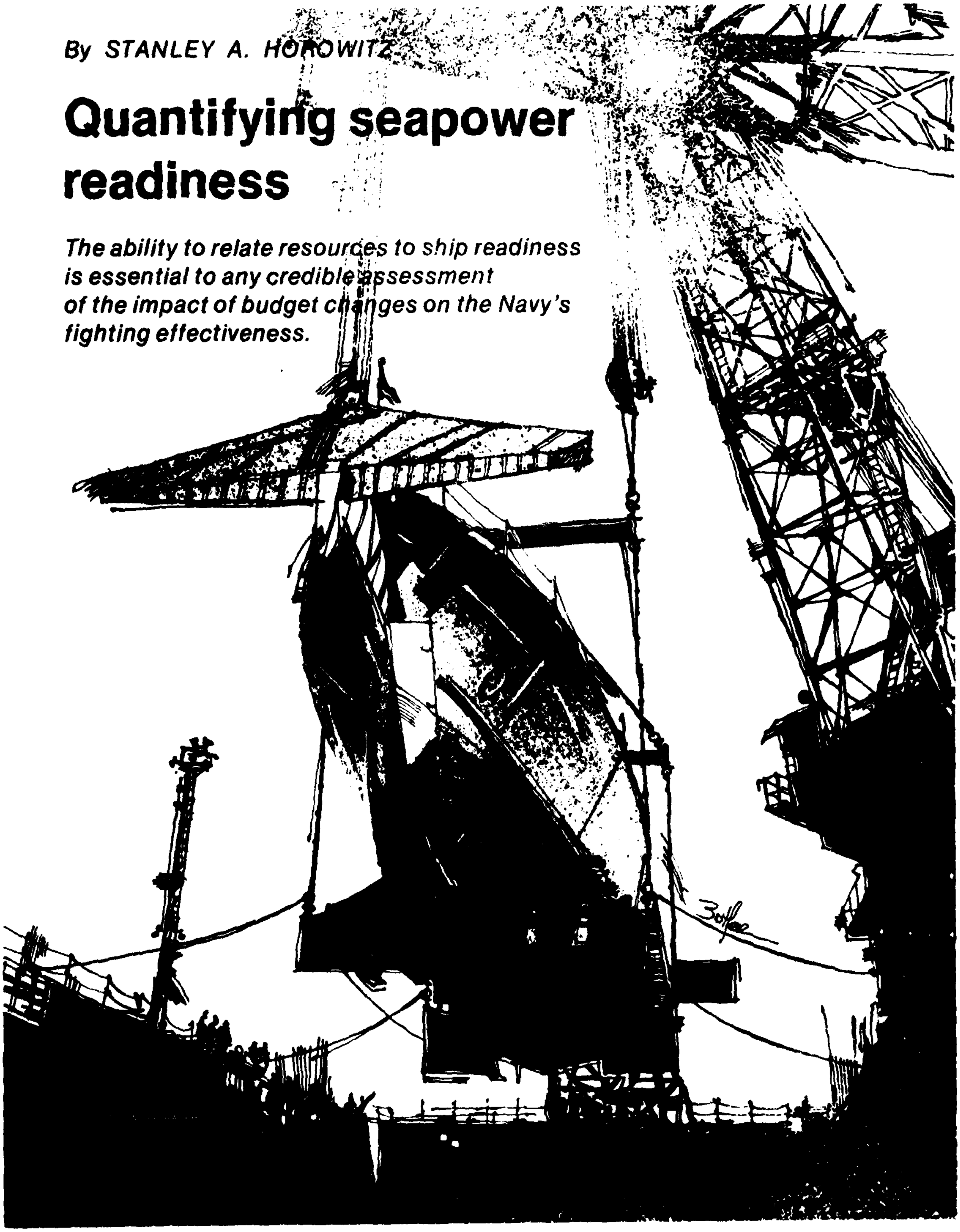
Quantifying seapower readiness

The ability to relate resources to ship readiness is essential to any credible assessment of the impact of budget changes on the Navy's fighting effectiveness.



In the past two years, Congress has come to realize that it needs more precise data to better grasp the implications of its decisions on the funding of readiness-related accounts. Beginning with the 1978 Defense Authorization Act, Congress required the Department of Defense to include in its budget submission data that would indicate the effect of the requested appropriations on material readiness. The same act also requested DoD to compile a report detailing measurable materiel readiness requirements.

As the Office of the Secretary of Defense began instituting these requirements, it identified several major problems that were obstructing compliance. In general, there were no clearly defined or agreed-upon measurable materiel readiness requirements. Although goals for operational readiness are specified by several services, such goals generally are not relatable to any analysis of the required combat capability for wartime missions. Even more disconcerting is the fact that OSD does not have an ability to project the effect of appropriations on materiel readiness.[1]

Therefore, Congress is not alone in its ability to benefit from an explicit, quantitative method for showing the effect of outlays for readiness. Navy decisionmaking would also be greatly enhanced if it were armed with such data. Simply put, readiness-related data were not made available to the Congress before 1978 because the Department of Defense did not have sufficient data to estimate the impact of various resource levels on readiness. However, a continuing research program might put the Navy in a position to answer many resource-to-readiness questions for ships.

Readiness-analysis problem

The readiness-analysis problem consists of defining readiness, measuring readiness, relating resources to readiness, and evaluating the importance of readiness. It is impossible to solve the latter two parts of the problem without addressing how to define and measure readiness. The inability to clearly define the readiness of a force or unit has traditionally inhibited readiness analysis. This problem can be resolved by concentrating on aspects of readiness we can effectively measure, and by using suitable data to measure readiness. This approach has enabled researchers to develop successful and consistent relationships between readiness and particular kinds of available resources for ships.

While some observers have broadly defined readiness as *the ability of a force, unit, weapon system, or equipment to achieve a specifically defined wartime objective*, others, including members of the Department of Defense Readiness Management Steering Group, have defined it as *the ability of a force, unit, ship, weapon system or equipment to perform the function for which it is organized or designed*. While these definitions and concepts are not really consistent, they are indeed related. Readiness includes material, personnel, training, and supply components. These determine the mission readiness of individual units. Achievement of the ultimate goal—force effectiveness—requires consideration of such additional factors as threat, force size, capability, and strategy. A readiness researcher must select which aspect of readiness to analyze and evaluate. Whatever aspect is chosen, it must be appropriate to the situation and measurable, especially if an analysis is to reflect real-world rather than simulated data.

For example, in determining how to allocate funds for spare parts aboard a particular ship, one can focus on the material readiness of the ship to perform its designated missions. However, suppose a decision must be made between a temperamental, highly capable system and one that is simple but less effective. The ease or difficulty of achieving material readiness should enter into the decision, but the analysis must not stop there. Even the inclusion of unit effectiveness in the analysis may yield too narrow a perspective. In reality, before an accurate answer can be obtained, it might be prudent to model how groups of forces are likely to interact in combat.

Measuring the readiness of ships

If ship readiness is measured solely in terms of material readiness, analysts may avail themselves of the numerous data systems that concentrate on material condition. Two of these, the casualty reporting system and the maintenance and material management system are the Navy's regular material-condition reporting systems. Under these

[1] *Office of the Secretary of Defense Memorandum, Readiness Analysis, Washington, D.C., June 28, 1977.*

systems, reports are filed on most corrective maintenance actions, even if mission performance is not believed to be affected. A casualty report must be filed when a ship suffers an equipment failure that is believed to degrade mission performance if it cannot be repaired in 96 hours. Ratings range in severity from the mildest C2 category, indicating only a slight effect on the performance of one or more missions, to C4, the most severe, indicating substantial inability to perform at least one primary mission. Sometimes casualty reports in the C2 range that are filed aboard surface ships are used as a vehicle to expedite shipment of a needed part. This factor complicates the use of this system's data as a credible indicator of material readiness.

The unit reporting system extends beyond consideration of material condition. In the area of material condition, the system employs criticality diagrams to allow assessment of mission material readiness. The force status system, a predecessor to the unit reporting system, allowed considerable discretion to be exercised by commanding officers in assessing material readiness. This appears to be no longer the case.

Two other systems produce readiness-related data from ongoing inspection programs. The Board of Inspection and Survey inspects more than 100 ships a year. After each inspection, the board assigns the ship a material condition index score which is the sum of grades in 25 categories including steaming, firefighting, combat, and habitability. The Propulsion Examining Board conducts inspections as part of the steam propulsion plant improvement program and has been inspecting specific classes of boilers since 1973. It grades ships according to materials, preservation, administration, knowledge, and casualty control. The materials segment of their findings is closely connected to material readiness. While the Propulsion Examining Board provides a summary rating, its inspections do not address the condition of weapons or of other non-propulsion equipment.

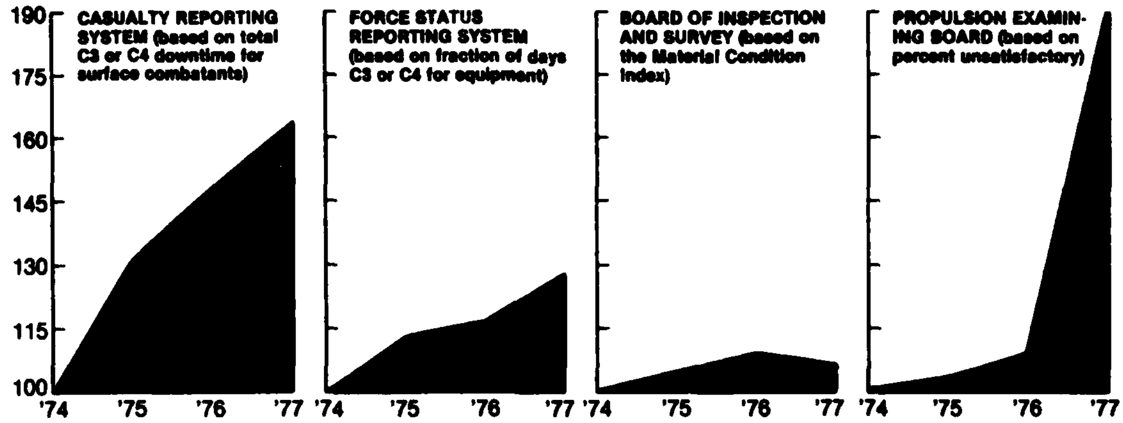
Finally, recent work shows that it is possible to develop data on material readiness from the engineering logs of surface ships. While this is a tedious task, the result is dependable. Interestingly, log entries noting out-of-commission equipment correlate well with casualty reports.

Some resource-to-readiness analyses require concepts of readiness that encompass more than material readiness, and data to develop and refine these concepts are marginal. Exercise results have been used successfully to provide operational readiness measures for aircraft, but their application to ships and other forces has been very limited because they are difficult to interpret consistently. Both exercise and inspection results provide only snapshots of readiness and don't provide a mechanism to continuously track the readiness of a unit. Although the unit reporting system provides continuous measures of personnel, training, supply and overall unit readiness, the relationship between these indicators and the actual ability of ships to perform missions is still unverified.

Fortunately, it is not mandatory to measure readiness according to a particular definition in order to use that definition in an analysis. While pure statistical analysis requires real data, the usefulness of this approach is largely confined to studies of material readiness. At present, more effectiveness-oriented studies must rely on simulated data. If the simulation accurately reflects the details of the process being modeled, the output can be used to study readiness questions. Admittedly, effectiveness-oriented simulations exist, but seldom have they been developed or exercised with the purpose of uncovering and understanding readiness-related issues. At least for now, the scope of efforts to relate resources to readiness for ships must largely be limited to analysis of material readiness.

Even when an analysis is restricted to material readiness, most of the available data have some shortfalls. Much of the data is generated from reports ships make themselves, and self-reporting is not necessarily accurate reporting. Board of Inspection and Survey and Propulsion and Examining Board inspections are the cause of intense preparation that may not reflect the usual level of materiel readiness. The Center for Naval Analyses' cognizance of these shortcomings is reflected in its ship maintenance and supply study in which fleet-readiness trends from 1974 to 1977 were analyzed using four sources of material-readiness data. The results shown in Figure 1 compare the levels of the four material readiness indicators in 1977 relative to their levels in 1974. In each case, the higher numbers indicate improved readiness, with substantial agreement among the four data

Fleet readiness trends were analyzed from 1974 to 1977 using four sources of material-readiness data. In all cases the sources indicated improved readiness over 1974 baseline levels.



sources. All sources show improvement from 1974 to 1975, from 1975 to 1976, and from 1976 to 1977, except the Board of Inspection and Survey data which shows deterioration between 1976 and 1977.

Additional analyses were performed correlating different measures of material readiness across ships. Casualty report indicators have been compared with Board of Inspection and Survey and with maintenance and material management indicators; force status reports have been correlated with Board of Inspection and Survey results. Cross comparisons yielded significant correlations in all instances.

These analyses indicate that ships rated in good condition according to one indicator are likely to be rated in good condition according to others. Moreover, different indicators show similar trends over time. This consistency promotes the belief that existing data can be used to analyze material readiness if multiple data sources are used.

Relating resources to readiness

Reasonable indicators of material readiness can be derived from existing data. Similarly, statistical analyses that relate available resources for particular ships to the material readiness of the ships have been successful.

In FY76, an experimental program was implemented. Under the program 41 ships received unlimited funds to buy repair parts. A control group of 47 similar ships did not receive the unlimited funds. In FY77, the control ships began receiving increased funding, but not at the level of the 41 pilot ships. To measure the impact of the additional money on material condition, analysts used data from casualty reports and the Board of Inspection and Survey. The analysts performed a regression analysis that corrected for pre-program differences between the pilot ships and the control ships and for time trends independent of the program. Ship age was held constant, as were fleet type and ship type.

The analysis revealed that the pilot ships averaged 68 fewer days of serious C3 or C4 casualty report downtime per quarter. The control ships averaged 38 fewer days of downtime once they began to receive additional funds. In both cases, an $800 investment per ship resulted in a one-day decrease in C3 and C4 downtime. This result was verified using Board of Inspection and Survey data.

Another statistical analysis relating resources to ship material readiness highlighted the impact of the number and quality of enlisted maintenance personnel on the amount of casualty report downtime suffered by their equipment. Six occupations,

Figure 2. In one study, it was found that boiler-related downtime could be reduced by 50 hours per month by altering the number and quality of enlisted maintenance personnel to correlate more directly with the complexity of the equipment.

Propulsion plant	Crew characteristic
Two screws, 1200 p.s.i.	Average score on shop Practices Test
	Percent E-4 or below
	Percent E-8 or above
	Percent with length of service under 1 year
	Percent with length of service 1-10 years
	Average number of school-related Naval Enlisted Classifications per man
	Percent unmarried
One screw, 1200 p.s.i.	Percent with length of service under 10 years
	Average number of Navy schools attended per man
Two screws, 600 p.s.i.	Crew size
	Percent with length of service under 10 years

or ratings, were analyzed and numerous potential indicators of crew quality were examined including education, entry test scores, paygrade, years of service, amount of sea duty, crew turnover, Navy schooling, marital status, and race. The study uncovered ways to improve the material readiness of boilers by increasing personnel quality or quantity (see Figure 2). One important finding was that higher skill levels are much more important in dealing with more complicated two-screw, 1200 p.s.i. equipment. The derived relationships can be used to predict the efficiency and effectiveness of alternative personnel policies about training and recruitment.

There are instances when resource-to-readiness relationships can be derived by using tools that are less complex than regression analysis. The possibility of halving the number of C3 or C4 casualty reports by easing the rules under which vital parts can be stocked aboard ship was identified by calculating the expected number of failures for various categories of parts on one particular ship. Additionally, simulation methods can be used to develop resource-to-readiness relationships. However, this approach is more common in the aviation arena and has been of less utility when applied to vessels.

One noteworthy ship simulation is the SHIP II model developed at the Naval Personnel Research and Development Center. This model is a total simulation of the interactions among personnel, equipment, and operational scenario. It is designed to simulate the workload associated with the normal activities conducted aboard a Navy ship and it randomly samples events from empirically derived frequency distributions. Events include assignment of crewmen to watches, maintenance, administration, and support work; equipment failures; training exercises and classes; and normal operations such as underway replenishment and anchoring. The model can be used to test the implications of various manpower and personnel policy decisions such as manning a ship with a reduced crew or altering the paygrade or Naval Enlisted Classification distributions. With its ability to measure workload and derive material readiness indicators, the model is a tool with which to assess the cost of reducing manpower levels. Although the model does not adjust for qualitative factoring by allowing more experienced people to perform repairs more quickly, it does have a wide range of applications.

Although there are many problems in identifying and relating changes in a unit's level of resources to its readiness, such relationships can be developed. And while this might help in justifying some budget requirements, it would not necessarily answer questions about the impact of more general budget changes. To the extent that Congress is concerned about knowing and understanding the expected impact of budget changes on readiness, it is necessary to know how changes in funding aggregates that are visible at the budget level relate to changes in resources.

The implications of a budget change for the nature, quantity, and location of resources being bought are not always obvious. The impact of a budget change on a program depends upon where or how a given cut will be sustained. An across-the-board personnel cut will have a greater impact on readiness than a cut tailored to avoid critical ratings. Therefore, every budget change of major interest should be examined individually to determine which resources will be affected. Logic diagrams that aid this task can be developed, but the ability to automatically relate budget changes to readiness will be hampered by the uncertainty about where the changes will be made.

The difficulty of analyzing operational readiness is a major shortcoming that signifies an inability to adequately evaluate the contribution of many kinds of schooling and unit training to national defense. Unfortunately, the Navy has no yardstick against which to measure the contributions of operators, even though a ship is much more than a repair shop.

While relationships between resources and readiness have been developed, many important ones remain undeveloped or incomplete. The Navy now spends more than $2 billion on overhauls, and a study examining the effects of overhaul spending on the material condition of three classes of ships is only now nearing completion. The readiness implications of intermediate maintenance activities remain unanalyzed for ships. Indeed, much more can be learned about the contribution of improved supply techniques and better maintenance personnel.

Assessing the impact of budget changes

The goal of relating resources to ship readiness is the assessment of the impact of budget changes on the effectiveness of the Navy as a fighting force. A three-pronged approach to solving the less complicated aspects of the problem while simultaneously working on the tougher aspects calls for analysts to develop more material-readiness relationships, work on usable indicators of operational readiness, and analyze the value of readiness. Progress can be made on this third requirement even if the most appropriate indicators of operational readiness are lacking. Perhaps engagement models could be useful in such instances.

Some feel that readiness has been shortchanged to increase the number and complexity of the weapons the Navy buys. Analysis to illuminate this issue would be timely and appropriate.

One reason we are not further down the path is that nobody is responsible for shepherding readiness research. Despite the fact that the Center for Naval Analyses has reviewed over 130 readiness-related studies, there is no central point for tracking these studies, identifying areas that have been well researched, selecting the most promising areas for new research, or converting research findings into management tools. To remedy these deficiencies, the Navy should examine the possibility of designating a single office to monitor and manage future research on resource-to-readiness relationships and readiness trends; coordinate responses to readiness questions; and act as an advisory board to the Chief of Naval Operations on readiness matters.

The development of models to improve management and fulfill congressional requirements is a long-term effort. In the meantime, questions on readiness will have to be answered on a case-by-case basis. An office dedicated to ensuring that the answers are related to a coordinated, ongoing research program would certainly make the job easier. DMJ

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**The Graduate School of Management, University of Rochester

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